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AUTHOR Smith, Allan L.
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ABSTRACT

Following a brief description of the microcomputing program at Drexel University, which requires all freshman to have access to a personal computer and offers Macintosh microcomputers and software at a low cost to entering freshman, this paper summarizes the written sources of information on the program. Four examples of how currently available Macintosh software has been integrated into the core curriculum taken by all freshman engineering and science majors describe the use of: (1) word processing and online database searching in freshman composition; (2) Pascal programming language in the introductory computer programming course; (3) electronic spreadsheets in introductory physics and chemistry; and (4) a molecular drawing exercise in elementary biochemistry. Also outlined are the ongoing investigation of applications for existing Macintosh software in science and engineering courses and the design and development efforts by science and engineering faculty and the Instructional Support Group of the University Computer Center for new software to support undergraduate instruction. Ten references are listed. (LMM)

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# USING THE APPLE MACINTOSH TO EDUCATE ENGINEERS AT DREXEL

**Allan L. Smith**
**Department of Chemistry**
**Drexel University**

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# USING THE APPLE MACINTOSH TO EDUCATE ENGINEERS AT DREXEL[1]

## Introduction

Starting with the entering class of 1983, Drexel has required all of its freshmen to have access to a personal computer. One of the primary goals of this program is to make computational power available to students at reasonable cost right where they work at learning - at their desk in the dorm or at home.

The University made arrangements with Apple Computer to be able to offer a Macintosh and five software packages to entering freshmen for $1,000. The software includes MacWrite (word processor), MacPaint (drawing and graphics), Multiplan (spreadsheet), Pascal, and BASIC. The first distribution of Macs occurred in February, 1984; 1900 freshmen and over a hundred faculty purchased systems, and almost 200 more were allocated to academic departments within the university. Distribution to this fall's freshman class will occur in October. In this paper I will briefly summarize the written sources of information on the Microcomputing Program, describe how existing Macintosh software has been used in teaching freshman courses this past spring, and outline the ongoing instructional software development efforts for the Macintosh by science and engineering faculty.

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[1] Paper to be published in Proceedings of the 1984 Frontiers in Education Conference, Philadelphia PA, October 3-5, 1984.

## The Microcomputing Program

In the fall of 1982 Drexel announced its intention to require access to a personal computer of all freshmen. A Microcomputer Selection Committee was appointed at that time to define broadly the educational goals of the program, to work out the specifications for the microcomputer system, and to recommend computers systems which would meet these specifications. This report has been published elsewhere (1). In mid 1983 a progress report on the microcomputing program was presented at another IEEE Conference (2). This report described the computing environment at Drexel, the chronology of the decision to require personal computer access for every student, and initial efforts at developing the faculty's fluency with personal computers. A more current update was presented in June, 1984 at the ASEE Conference (3), in which issues such as the impact of personal computing on the university and on the curriculum were raised.

Two articles in popular microcomputing magazines have also appeared (4,5).

The university has prepared a series of information pieces on the Microcomputing Program. "Choosing the Machine" describes the selection decision. "Preparing the Faculty" summarizes the faculty development effort in support of the Microcomputing Program. "Organizing the Program" discusses the logisitics involved in introducing microcomputing at Drexel (5).

## Using Existing Software in Freshman Courses

Following are four examples of how presently available Macintosh software has been integrated into the core curriculum taken by all freshman engineering and science majors (over 1200 students):

- word processing and on-line database searching in freshman composition;

- Pascal in the introductory computer programming course;

- electronic spreadsheets in introductory physics and chemistry;

- molecular drawing exercise in elementary biochemistry.

1. Freshman Humanities Sequence. Every freshman is required to take three terms of humanities courses: Composition, Reading and Research, and Techniques of Analysis and Evaluation. Writing comprises a major part of the assignments in these courses. Faculty anticipated that easy accesibility to word-processing would have an impact on the way students learn to communicate in writing. While Epstein (7) and Scheffler (8) have elaborated on this theme, faculty have not had enough experience with Macintoshes to be able to provide other than anecdotal evidence that word processors help students write. One incident suggests this, however. Computers were distributed to last year's freshmen during the last week of the winter quarter - the week that term papers in the Reading and Research course were due. Without any formal training from university faculty or staff, several hundred students who received Macs that week were able to learn to use MacWrite well enough to compose, edit, and print their term papers by the end of that week. A number of students said that having a word-processor made it easier to START putting their ideas down "on paper".

Another project, not initially related to the Macintosh but evolving in that direction, is the use by freshmen of non-line database searching techniques in researching term papers. A room with a number of hard-copy terminals connected via Telenet to the Bibliographic Retrieval Services' on-line catalog of databases was available to all 1600 students enrolled in the Reading and Research course in the winter term of 1984.

Faculty brought their classes to that room and taught the strategies and the syntax of simple searches, and students then researched their own term paper topics on-line. Kollmeier and Staudt (9) have discussed the results of this project. At present, a Macintosh-based search simulator is being developed which will allow students to learn the syntax of searches without being connected to the database. The hard-copy terminals will be replaced with Macintoshes this fall.

2. Introductory Computer Programming. For many years all science and engineering freshman have been required to take a one-term computer programming course during their first term at Drexel. In the fall of 1983 this course was an introduction to structured programming methods using FORTRAN 77, taught by members of the physics faculty. The university's Prime 850 computer system (processing power 4 MIPS, memory 4 MBytes, disk storage 300 MBytes, 128 terminals) supported a class of 1200 students. Using the Mac in last year's course was not possible, since it was not available until January, 1984.

This past spring a joint committee of science and engineering faculty recommended that the introductory computer programming course be restructured. It was decided that the language be changed from FORTRAN to Pascal, and that the new Macintosh Pascal programming environment be adopted so that sudents can use their own computers to learn to program. This programming environment has many features which make it particularly attractive for the novice programmer: multi-window display of source code, text, and graphic output; some syntax checking at the time of statement entry; automatic formatting, useful in accentuating program structure; single-step execution of programs, with full display of intermediate variables; easy setting of breakpoints and examination of the values of intermediate variables; full access to the extensive graphics

capabilities of the Macintosh, to name a few. A joint faculty team from physics and computer science worked throughout the summer to restructure the curriculum and will be teaching the course this fall.

It is interesting to compare the computing facilities used by this introductory course last year and this year from a hardware point of view. The number of computers has increased from one to 1200; the number of video display terminals from 128 (80 character by 24 line) to 1200 (bit-mapped graphics, 342x512 pixel); the total amount of random-access memory available to students from 4MB to 150 MB (1200 * 1/8); the total processing power from 4 MIPs to 300 MIPs (1200 * 1/4); the total disk storage per student from 64 kBytes to 400 kBytes (additional 400 kB increments are available for $3.50 per disk). The most common complaint from last year's class - standing in line for access to a terminal - has been eliminated.

3. Spreadsheets in Introductory Science Courses. Much of the content of today's university-level introductory physics and chemistry courses involve calculations. The tools scientists have used for their calculations have of course changed with the march of technology, which has made ever more powerful computational machinery available to students. When slide rules became cheap and widely available, the neces- sary calculations for determining the dissociation of a weak acid became accessible to every member of the class, but the number of algebraic steps needed to solve the problem made laborious to solve such a problem with a slide rule. The advent of four-function calculators in the late 1960's brought another increase in the efficiency with which the numerical steps in problems were carried out, but the approximation methods remained because of the inconvenience of carrying out more exact methods (i.e., solving a quadratic). Using the programmable calculators of the early 70's, the solution of a weak acid equilibrium problem can be reduced to a sequential process in which the necessary information is provided step-by-step and the calculations are done with great speed and accuracy. Unfortunately most people do not think in a sequential manner, and the structure

imposed on the problem by the linear medium of a program- mable calculator often hides from students the key relationships between quantitites and solution steps so important in understanding the problem.

Enter the stand-alone, microprocessor-based personal computer of the late 1970's. One of the most popular pieces of software for personal computers has been the electronic spreadsheet. Conceived of as a highly interactive and visual means of entering both numerical and textual information in tables and then performing computations on those data, the spreadsheet found immediate acceptance in the financial world. Although almost all of the applications of electronic spreadsheets presented in the literature have been in business, there is a nascent literature on using spreadsheets in other disciplines, and a growing realization that spreadsheets are general purpose programming tools for solving computational problems (10).

The basic data structure observable to the user of an electronic spreadsheet is the table: labelled rows and columns of numerical or textual information. For a chemist, by far the most important and frequently used table is the Periodic Table of the elements. In general chemistry we introduced students to the use of a spreadsheet by showing them how to incorporate the Periodic Table into a spreadsheet in order to calculate molecular weights and percentage compositions. The first step is to enter a subset of the Periodic Table in two columns of data: the symbols of the elements and their atomic weights. In the third column, the number of atoms of that element in a chemical formula are entered. The fourth column is a product of columns two and three. By summing the fourth column, one has the molecular weight. It is a simple matter to add a fifth column to compute the weight percentage composition of the compound.

A spreadsheet module has also been developed for solving for equilibrium concentration of all species in the general chemical reaction

$$a\,A + b\,B = c\,C + d\,D$$

given initial concentrations of each species. The reaction extent E is defined as E = -[ (A) - (A)o ]/a, where (A) and (a)o are the final and initial concentrations of species A. The quantitiy E can be varied in the model, and the concentrations of all four species are computed from their initial values and the reaction extent. The reaction quotient,

$$Q = (A)^a * (B)^b / [(C)^c * (D)^d]$$

is computed. The reaction extent is varied until Q reaches its equilibrium value, K. Unlike all treatments in general chemistry texts, no approximate methods are needed to solve complex equilibrium problems such as the reaction of nitrogen and hydrogen to form ammonia.

A series of spreadsheet models for calculating concentrations and pH's of solutions of weak acids, weak bases, and buffer solutions has been developed by Drexel chemist James P. Friend. A problem assignment was given this summer in which students were asked to use these models to determine how the fraction of dissociation of a weak acid varies with changes in initial concentration and in ionization constant.

Spreadsheets lend themselves admirably to problems of data analysis in laboratory situations. In the introductory physics laboratory on measurement of specific heats of several substances, students were given a skeletal spreadsheet to do some of the initial computations and then asked to refine and develop the spreadsheet to complete the calculations. Another spreadsheet model was developed to fit a series of data pairs to the relationship y= mx + b by the method of least squares, in which residuals were displayed in bar graph form.

For an elective course "Introduction to the Chemical Engineering Profession", Dr. John Tallmadge has developed spreadsheet models to perform simple material balance calculations for industrially important processes, such as the production of sulfuric acid.

4. Molecular Drawing in Biochemistry. Introductory biochemistry is a

highly visual subject, at least the way we teach it in the third quarter of the general chemistry course at Drexel. One of the key ideas is that large biochemical molecules are built up of smaller parts and functional groups. We have found that the MacPaint drawing program on the Macintosh is an excellent way to give students a tool with which they can construct good drawings of large molecules.

The large lecture hall in which general chemistry is taught is equipped with a video projector connected to a Macintosh modified for video output. Dr. Friend, who taught the biochemistry component of our introductory course this past spring, decided to use MacPaint to prepare all of his visuals, rather than relying on overhead transparencies. Because he projected these drawings in the classroom, he could modify them in real-time and thus obtain an elementary form of animation. For example, he used the "lasso" feature of MacPaint to remove a hydroxyl group from one amino acid and a hydrogen atom from the amine group of another amino acid, then moved the two groups together to form the peptide bond and complete the condensation reaction. After finishing the lectures, Dr. Friend then gave a problem assignment in which students were asked to construct various biochemical molecules using MacPaint, ending up with a small segment of the DNA double helix. Several students remarked on how well they understood these structures after having been required to build them in this way.

**Software and Curriculum Development by Drexel Science and Engineering Faculty**

The information piece "Preparing the Faculty" (6) describes the process by which a faculty member can apply to the university for the resources he or she needs to develop either new software or new uses of existing software relevant to undergraduate courses. Eighty-four faculty

have received grants for this purpose through a peer review process, almost fifty of which have been in science and engineering. Here are some of the projects that have received support to develop applications of existing Macintosh software in science and engineering courses:

- applications of a spreadsheet in calculating quantities in the cycles treated in engineering thermodynamics.

- the use of MacPaint and MacDraw in Introductory Engineering Graphics.

- the use of the equation-solving package TK!Solver as a problem solving tool in various areas of science and engineering.

The other major area of curriculum development is the design and implementation of new software to support undergraduate instruction. One key idea is that of a development team, consisting of the content expert (the faculty member), the implementer (a staff or student programmer), and the learning or curriculum specialist with expertise in instructional design. In broad categories, the software being developed consists of problem-solving tools, simulations, and tutorials. Following is a partial list of projects underway at present:

- the analysis of EKG's (S. Dubin, Biomedical Engineering);

- a database for structural materials (E. Doheny, Civil Engineering);

- instructional software for circuit design (E. Gerber, Electrical and Computer Engineering);

- a simulation for the testing and analysis of digital filters and digital systems (B. Onaral, Electrical and Computer Engineering);

- software for heat transfer and fluid dynamics (B. Farouk, Mechanical Engineering and Mechanics);

- self-paced instructional software for statics (D. Thomas, Mechanical Engineering and Mechanics);

- a visual scheme for identifying plants (A. List, Biological Sciences);

- a software-based molecular models kit (A. Smith, Chemistry);

- classroom demonstrations and interactive tutorials in elementary organic chemistry (S. Solomon, Chemistry);

- an interactive program for stereochemical identification of organic molecules (P. Wade, Chemistry);

- demonstrations, drills, and practice units in elementary calculus (A. Herr, Mathematical Sciences);

- software to support instruction in analysis (B, Kolman, Mathematics);

- computer-based lecture demonstrations in elementary mechanics, optics, and acoustics (L. Cohen, Physics);

- pre-laboratory and laboratory analysis tools in introductory physics (W. Eidson, Physics).

In addition, there are several projects underway in the Instructional Support Group of the Computer Center - the group charged with software support for the Macintosh:

- a software-based electronic construction set for assembling and testing simple analog circuits, and a comparable construction set for simple digital circuits.

- a general scientific plotting package;

  a package demonstrating the features of the Macintosh user interface.

Although software development for the Macintosh is not straightforward due to the sophistication of the user interface and the system software, working packages suitable for student use are beginning to emerge from this effort and to be tested with students. Faculty are also developing more judgement as to what constitutes good and poor instructional uses of microcomputers.

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10. For example, see Alan Kay, "Computer Software," *Scientific American* (September 1984): 30.